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A combined global and local identification approach for LPV systems

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1 Introduction

Linear parameter-varying (LPV) systems are nonlinear systems described by a linear model coefficients of which vary as a function of the so called *scheduling parameters*. The literature on LPV system identification typically distinguishes between two different identification approaches - global and local. Global techniques directly identify an LPV model based on data obtained from an experiment where both the input signal and the scheduling parameters are continuously changing. Local identification techniques typically consist of two steps. In the first step, several LTI models are identified based on input-output data for various fixed values of the scheduling parameter. In the second step, the LTI models are interpolated yielding a parameter varying model.
The global approach may offer high accuracy in predicting the system behavior under changing scheduling parameter conditions, in exhange for involved experiment design related to ensuring persistancy of the excitation. What goes in its favour is also the fact that *dynamic scheduling dependency*, i.e. system's dependency on time-shifted instances of the scheduling parameters, can only be detected through a global identification experiment. The local approach, on the other hand, can accurately identify only systems with *static scheduling dependency* - dependency on the instantaneous time values of the scheduling parameters, but can to a large extent rely on the well-studied linear time-invariant (LTI) identification methods.

2 Methodology

Although different, data originating from global and local experiments both provide valuable information that, when put together, gives a more complete picture of the system at hand. Our research is currently focused on the possibility of combining the two approaches. We consider the nonlinear least-squares identification framework for LPV systems [1], convenient for several reasons: it easily combines data originating from different experiments, the data it engages can be in the time and/or the frequency domain, it allows to emphasize particular experiments by simply employing weighting matrices, and the solution can be efficiently found by the well-known Levenberg-Marquardt algorithm. In this way, it is possible to balance between the importance of the system's behavior under changing scheduling parameter conditions, and the behavior for fixed operating conditions.

Table 1: Mean squared error of the identified LPV model calculated with respect to the global validation data - first row, local identification data - second row, and local validation data - third row; averaged over 100 identification proceedings.

$\alpha = 0.005$	$\alpha = 0.5$	$\alpha = 0.995$
$2.876 \cdot 10^{-1}$	$5.478 \cdot 10^{-2}$	$4.127 \cdot 10^{-2}$
$4.697 \cdot 10^{-4}$	$7.247 \cdot 10^{-3}$	$8.543 \cdot 10^{-3}$
$4.901 \cdot 10^{-4}$	$4.017 \cdot 10^{-3}$	$4.505 \cdot 10^{-3}$

3 Simulation example

Assume a single-input single-output discrete time LPV system of second order, with one scheduling parameter. We combine data from a global time domain experiment and local data: five frequency response functions each obtained for a different fixed value of the scheduling parameter. The total number of data samples in the local experiments equals the total number of data samples in the global experiment. To balance between the global and local behavior, we introduce weighting scalars α and β for the global and local data respectively, with $\alpha + \beta = 1$, $\alpha > 0$, $\beta > 0$. As the initial guess for the LPV identification, the LTI model identified for the scheduling value in the middle of the operating range is taken.

The results given in Table 1 clearly show that putting emphasis on one approach gives better results in the context interesting for that approach. Nevertheless, a compromise between the two seemingly exclusive objectives ($\alpha = 0.5$) is also achievable.

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